J5.1 A PRELIMINARY EXAMINATION OF THE PERFORMANCE OF SEVERAL MESOSCALE MODELS FOR CONVECTIVE FORECASTING DURING IHOP

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1. INTRODUCTION

The International H_2O Project (IHOP) is an extensive field project in the Southern Plains carried out from 13 May and 25 June of 2002. The main focus of IHOP is to improve the characterization of the four-dimensional distribution of water vapor and its application to improving the understanding and prediction of convection. The four main components of the program are quantitative precipitation forecast (QPF), convective initiation (CI), atmospheric boundary layer processes, and instrumentation. An important aspect of studies that will use the data gathered during IHOP will be to evaluate the impact of the experimental moisture measurements on forecasts from high-resolution numerical models. Given their long history of developing and running analyses and model systems, the NOAA Forecast Systems Laboratory (FSL) will be involved in this post-IHOP field phase effort. During IHOP itself, FSL will be running experimental versions of local and national scale models, both to assist with nowcasting and short-range forecasting for the project, and to provide a baseline of model performance.

The FSL has been involved in model development through two main efforts, the Rapid Update Cycle (RUC, Benjamin et al. 2002) model, and with local-scale models designed to run onsite at a National Weather Service Forecast Office (WFO). The advantages to locally running a small-scale model include the ability to incorporate local datasets that may not be available at a national center, using an analysis system that combines the various datasets and incorporates quality control to arrive at a local analysis that can be used to initialize the model. For tests at FSL, the Local Analysis and Prediction System (LAPS, McGinley et al., 1991; homepage at http://laps.fsl.noaa.gov) has been developed for this purpose, as well as to provide analyses that use local and other data and have a frequent update cycle. LAPS is currently running in AWIPS at WFOs on an hourly cycle with a 10-km grid spacing. The LAPS analysis has been used over the last several years to launch several models at 10-km horizontal grid resolution, including the Eta, MM5, and two versions of the Colorado State University RAMS model, with displays on the FSL Web site. The current configuration, which is used experimentally at the Boulder WFO, is a LAPS analysis with a diabatic initialization (hotstart) version of MM5. In this scheme the LAPS cloud analysis is used to input an assumed vertical velocity profile where sufficiently deep clouds are present at initialization time (Schultz and Albers 2001), as a means to avoid model spin-up time to generate precipitation (Shaw et al. 2001). The three-dimensional dynamical relationship between mass and momentum is adjusted by the LAPS balance algorithm (McGinley and Smart 2001) to force consistency with the diagnosed cloud vertical motions and allow for a smooth model start. The model is run 4 times a day out to 24 h and available at the Boulder WFO on their AWIPS workstation.

During IHOP a 12-km horizontal resolution MM5 hotstart initialized with LAPS was run, with a nested 4-km version covering the IHOP experimental domain, (Fig. 1). LAPS also was used to initialize a similar 12 and 4-km setup for the Weather Research and Forecast (WRF) model. The models run by FSL for IHOP are summarized in Table 1.

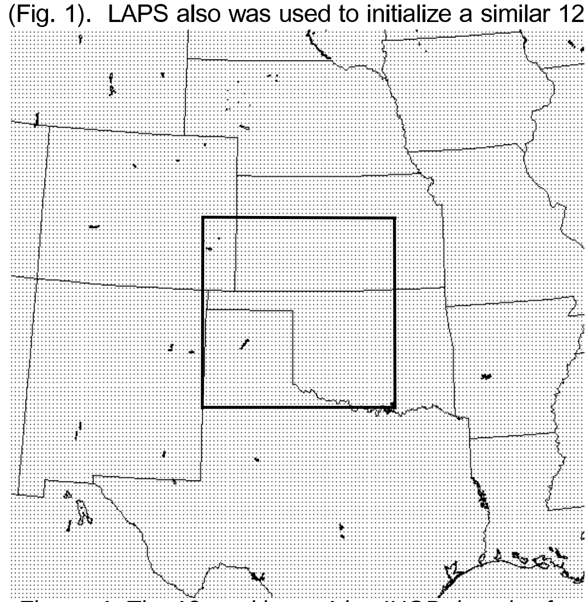
Figure. 1. The 12- and inner 4-km IHOP domains for the LAPS MM5 and WRF runs (points every 12 km).

The RUC model recently was upgraded to a 20-km horizontal grid resolution which became operational in April 2002. For IHOP a 10-km version (Benjamin et al. 2002) was run, similar to the runs during

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the last two years for PACJET. The RUC model employs a 3DVar analysis for the mass fields, and initial RUC hydrometeor fields are crudely adjusted to correspond to base scan reflectivity patterns at the initial time, but without any modification of the initial vertical velocity field (this being different from the MM5hot method). The experimental model runs for IHOP were archived by UCAR's Joint Office for Science Support at http://www.joss.ucar.edu/ihop.

Table 1: FSL models in IHOP

Model	x km	# vertical levels	Runs every x h	Out to x h
MM5hot	4	34	3	12
MM5hot	12	34	3	12
LAPSWRF	4	34	3	12
LAPSWRF	12	34	3	12
RUC	10	50	3	6-24

2. MODEL EVALUATION ACTIVITIES IN IHOP

Our real-time evaluation during IHOP involved a routine subjective evaluation of the performance of the various models. An online evaluation form was designed that enabled one of the participants, dubbed the "model evaluator," to document: 1) what the model was forecasting; 2) the relationship of various forcing features to the subsequent convection forecast by the model; and 3) the confidence in the forecast.

The form that FSL developed (online at http://www-ad/~kay/ihop/evaluation.pl) for our evaluations was modeled after similar evaluation activities that the Storm Prediction Center (SPC) had been involved in for the previous two spring seasons. The SPC activities were also intended to record real-time impressions of model forecasts, as well as to specifically evaluate various models daily in order to learn more about both the problems and the capabilities of the models. The SPC assembled a special research area for this activity, called the Science Support Area (SSA), which was located next to the operational SPC forecast area during IHOP. Since the SPC was involved in the forecasting for IHOP, evaluation activities were scaled back to concentrate on model performance for some operational and research models (see their webpage for the Spring 2002 program at http://www.spc.noaa.gov/exper/Spring_2002/). The two evaluation activities nicely complement each other, and expand the number of models that were evaluated in real time.

The model fields that were addressed on our online form for each model run are summarized below. For this form we concentrated on the main IHOP domain, roughly equivalent to the interior box shown in Fig. 1, and looked only at the first 12 h of the model forecast for:

- Initial boundary analysis, assessing how well the model resolved boundaries present in the actual data.
- Boundaries involved, recording the various boundaries that were forecast.
- Boundary/precipitation relationship, documenting how any precipitation forecast by the model was associated with a particular boundary.
- Maximum rainfall forecast by the model.
- Timing of convective initiation.
- Dominant convective mode. For the LAPS initialized models we used the model reflectivity field, while for the RUC this was implied from the precipitation field where possible.
- Parameter assessment, summarizing the nowcaster's impression of the forecast values of CAPE, CIN, surface mass convergence, and boundary structure.

For most of these characteristics we broke the 12-h period down into 0-3 h, 3-6 h, and 6-12 h, and for applicable questions we had the evaluators record their confidence in the model forecast. Of course there was also ample area to record notes, with suggestions to examine, where possible, key issues for IHOP, such as how the boundaries were defined, complex structures that might exist, and the structure of the boundary, such as its depth in terms of moisture.

Some of the characteristics evaluated were directly motivated by the overall goals of IHOP, such as the relationship between the various forcing features and the precipitation predicted by the models. The parameter assessment section followed a similar type of question that the SPC had used in their model evaluation activities the previous two years. The idea of model forecast storm type was motivated by a couple of unusually accurate model forecasts from our experimental local model during the 1999 convective season for two supercell days (documented for the last Severe Local Storms Conference, Szoke et al. 2000). The IHOP location in the southern Great Plains provided more opportunities for supercell and other more organized convective types than in Colorado, and so we added the storm type question to our evaluation. We recognize that more quantitative measures of model forecast accuracy are important, and there was a separate effort from FSL to evaluate scores for the different models during IHOP (http://www-ad.fsl.noaa.gov/fvb/rtvs/ihop/index.html).

3. AN EXAMPLE FROM IHOP

An early IHOP convective initiation case will be used to show the potential capabilities of the different models as well as the variations in the forecasts. Other examples will be shown at the conference.

The 23-24 May 2002 case was one of widespread convection and areas of convective initiation over much of the IHOP domain. It was a complicated case, with morning high based storms over northern Texas becoming more widespread and moving northeast to cover much of central Oklahoma by 1800 UTC (Fig. 2). There was a quasi-stationary frontal boundary stretching from the Texas Panhandle northeast across central Oklahoma into eastern Kansas, but much of the convection shown

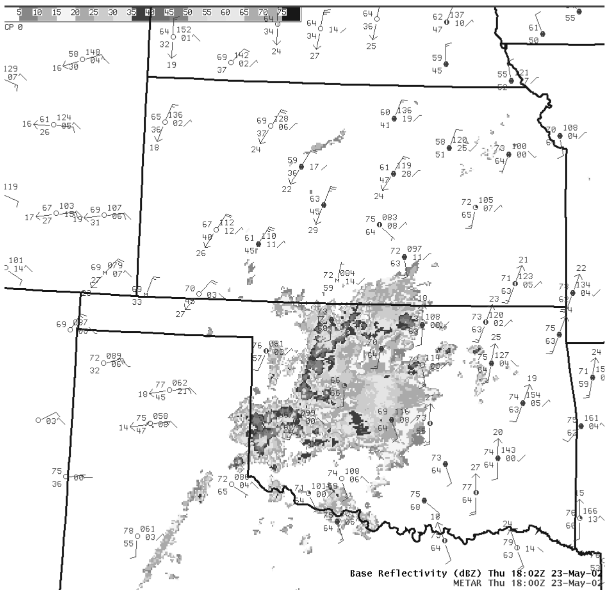

Figure 2. Radar mosaic (2 km resolution) with METAR plot at 1800 UTC 23 May 2002.

in Fig. 2 was not initiated by this boundary and instead was elevated or moved into the area from Texas. We will examine some model runs initialized at 1800 UTC, making it a good test of the ability of the models to capture initial activity. Subsequent to this time the area of precipitation continued moving northeast, but widespread outflow pushed the main boundary westward, initiating stronger storms that produced severe weather and one tornado late in the day over the Texas Panhandle.

The MM5 hotstart scheme captured the initial activity reasonably well (Fig. 3). Note that the 12-km MM5 fields are interpolated onto the 4-km grid to start the higher resolution forecast, so the derived radar reflectivity in Fig. 3 appears somewhat smoothed. The purpose of the hotstart is to hopefully gain an advantage in the prediction of convection over the first few hours of the forecast period when convection is already active and avoid the spinup problem that can exist in numerical models. An illustration of this capability can be seen by comparing the 3-h MM5hot 4-km run forecast (Fig. 4) with the observed reflectivity at 2100 UTC (Fig. 5). Between 1800 and 2100 UTC the more active convection in western Oklahoma weakened, with a new smaller line developing just to the east (arrow in Fig. 5). The model was able to capture this evolution, developing a new line near where it was observed while maintaining most of the other echoes. Over the next few hours during the afternoon the older convection over central Oklahoma continued to diminish. Outflow from this activity and the newer echoes noted at 2100 UTC sent the southwest-northeast oriented boundary slowly westward into the sunny Texas Panhandle, and in this area the boundary subsequently initiated strong convection beginning around 2200 UTC. Figure 6 shows a 2-km resolution radar mosaic for 0000 UTC on 24 May, with several strong storms in the Texas Panhandle, while what is left of the earlier convection has organized into a line farther to the east. The MM5 4-

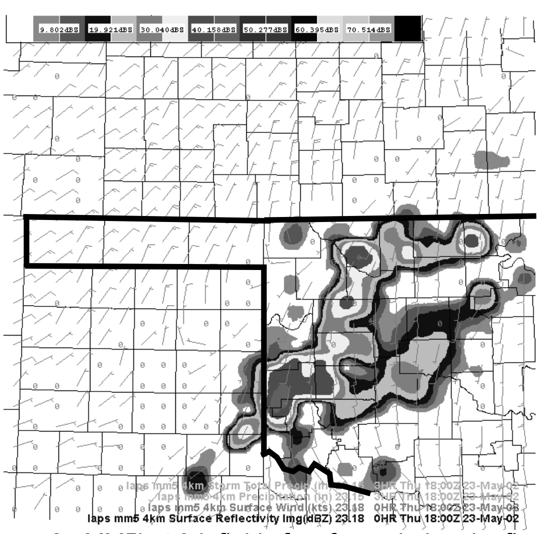

Figure 3. MM5hot 0-h field of surface wind and reflectivity, valid 1800 UTC 23 May 2002.

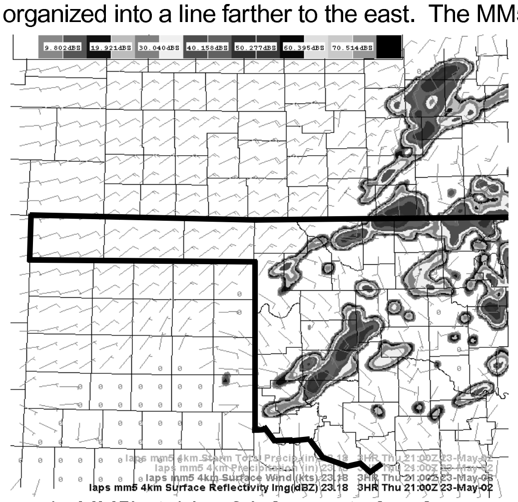

Figure 4. MM5hot 4-km 3 h forecast of surface wind and reflectivity valid 2100 UTC on 23 May.

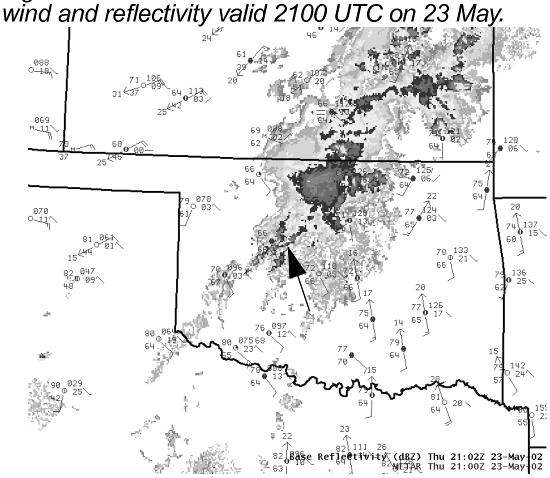

Figure 5. As is Fig. 2 except for 2100 UTC.

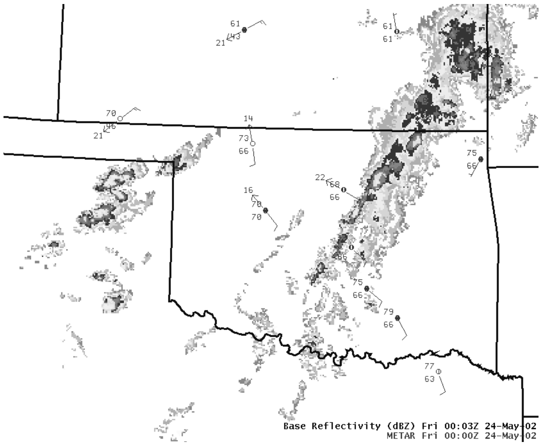

Figure 6. As in Fig. 2, except for 0000 UTC.

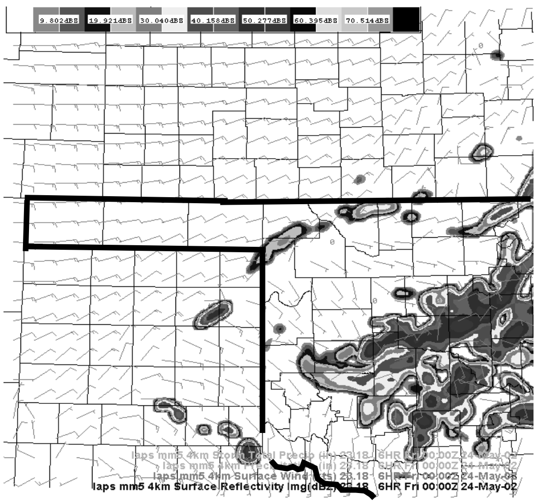

Figure 7. As in Fig. 4, except 6-h forecast valid 00 UTC.

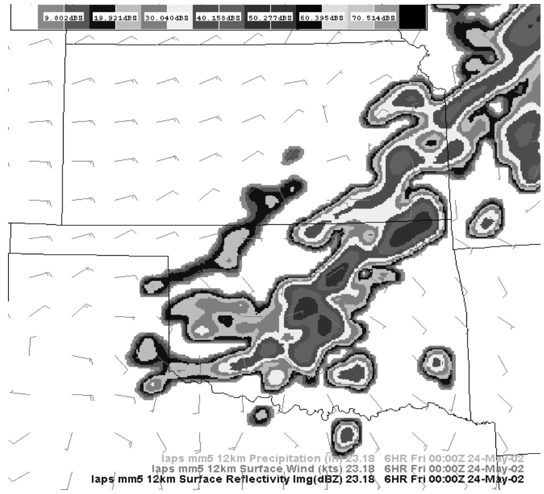

Figure 8. As in Fig. 7 but for the MM5hot 12-km run.

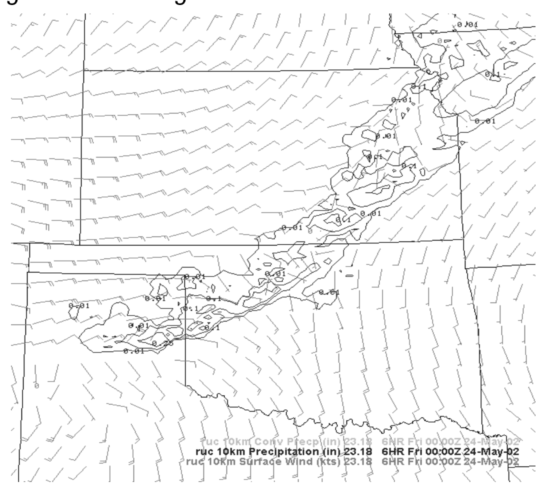

Figure 9. RUC10 6-h forecast of 1-h rainfall accumulation, valid 0000 UTC 24 May. Contours are for 0.01, 0.10, and 0.25 inches.

km model forecast from the 1800 UTC run valid at 0000 UTC is shown in Fig. 7, while the 12-km run forecast is in Fig. 8. The difference in the resolution is apparent in the structure of the cells forecast by the two models. Both models attempt to initiate new storms in the Texas Panhandle, with the 4-km run having stronger cells with more development farther west. The RUC10 forecast of 1-h accumulated precipitation (derived reflectivity is not available) and surface wind from the 1800 UTC run valid at 0000 UTC is shown in Fig. 9. More rain is successfully forecast over the Panhandle, but the RUC predicts a single line along the surface boundary and was unable to maintain the other weaker activity in central Oklahoma, perhaps illustrating the effects of the different initialization schemes for this case.

4. ACKNOWLEDGMENTS

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5. REFERENCES

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